New Lf Tracking Receiver (formerly Off-Air Frequency Standard)

These frequency standards are intended for indoor use and operate on LF or VLF frequencies, within the reception range of suitably stable, high-power, long wave transmitters. This range often exceeds 2500 km. Many such transmitters are locked and/or are traceable to well recognized national frequency standards via published data "post facto".

This series of standards yields a choice of price/performance trade-offs and is normally able to suit many medium to high frequency and (relative) time applications without resorting to the expensive acquisition and maintenance of atomic frequency and time standards. Within reasonable bounds, the results obtained are fully traceable to the appropriate (primary) reference source.

Quartzlock is pleased to announce an entirely new off air frequency standard after a quarter of a century of evolution. The outgoing Quartzlock models 2A and 2A-01 Droitwich 198 kHz Off-Air standards began production some twenty-five years ago. Significant design upgrades during this time have kept performance abreast of applications.

The 1999 model, 2A-X and 2A-Y are 99% new. The 1% unchanged is the chassis format. Like Rolls Royce, Quartzlock do not believe in changing the engine and the chassis design at the same time. “We had enough issues to deal with in the electronics without prolonged discussion about a new mechanical concept and our box works well so its not being fixed just yet”. All models contain a dedicated integrated - circuit receiver system with a very sharp bandpass crystal filter to extract the transmitter carrier (and reject all of the sidebands).

Models 2A-W and 2A-X both use VCXOs, running at 10 MHz, to provide phase locked loop (PLL) inputs and also to provide output signals-after appropriate processing. The Model 2A-Y has the VCXO replaced with a fast warm-up, directly heated crystal OCXO. This results in a lower phase noise - beyond the much reduced loop bandwidth, hence improving all of the noise performance figures.

The 2A-W delivers square waves (the user has the option to factory set these to sinewaves) from the front BNC sockets at 10 MHz, 5 MHz and at 1 MHz. The 2A-X and 2A-Y deliver 10 MHZ, 5 MHz and 1 MHz square waves and sine waves. These sine wave outputs are of exceptional purity and are derived from an internal, 10 MHz crystal oscillator. Output impedances are all at the standard, 50Ω level. Furthermore, they are able to drive any load, including TTL, HCMOS and misterminated loads (using 50Ω coaxial cable) with high predictability and minimum effort.

"Output fail” red warning LEDs indicate of loss of lock on the 2A-X and 2A-Y models. A high pitched beeper alerts the user to such a loss of lock. To monitor loss of lock during non-presence of the operator, the 2A-X and 2A-Y also have a “past output fail” red LED. There is no sound attached to this LED. Both LEDs operate on positive logic

Improvement in performance is as dramatic as the completely new RF and Quartz locking circuitry so short term stability and offset/accuracy beating CA code GPS frequency standards and almost equaling the lowest cost version of Quartzlock's unique carrier phase tracking GPS. The 2A-X also locks in one minute.

All of these models may have a small phase-temperature coefficient, but must have a zero frequency-temperature coefficient, due to their basic operating principles. Once the temperature settles down, even after a step change, the average output phase will tend to a constant value, and hence the average output frequency accuracy will tend to that of the transmitter - with zero frequency error.

Even for a FSD temperature change, the rate of internal temperature rise, and hence the phase rate (=frequency error) is limited, partly by the thermal mass and its inertia and by the low drift coefficient.

Such receivers do still suffer from several effects, which cause degradation of the accuracy of the output frequency; these include the following effects:

a). Possible transmitter outages: maintenance, severe weather, and power failure e.t.c.

b). Temporary local RFI. There is always the possibility of an arc welder, or similar being next door, or perhaps an electric railway or transit system. PCs and other modern electronic equipment are also regular offenders. Toroidal transformers, used in power supplies, with their high transient switch-on currents, electric kettles e.t.c also contribute to the overall level of the local RFI

c). Natural RFI: Aurorae, thunderstorms, atmospherics, and aircraft reflections….

d). Night - time skywave. This degrades the accuracy of the outputs of the models 2A-X and 2A-Y, as they try to follow the phase (distortion) of the receiver signal, in the medium term, i.e. at their loop bandwidths. It is impractical to make a simple receiver/PLL system with a very slow loop- not the least because the customer does not want to wait forever! - in order to reduce this effect. These interfering effects at VLF are also very slow and small (typically much greater than 100 seconds), yielding perhaps 1 part in 10^9 or at worst 1 part in 10^8 errors at the receiver's input frequency. They are therefore only partially amenable to slow PLL's as a solution - although they may improve matters by a decade or two.

However, neither the ionosphere, nor the receiver is capable of accumulating net phase (forever) and the frequency accuracy is hence only degraded at a given gate time, and is always able to be restored by using longer gate times - providing the receiver does not lose lock altogether. This may be verified over a 24 hour run, showing that the output phase always returns to the same place and that during each daytime period no cycles have been slipped. In fact, even if the receiver does loose lock (a very rare occurrence), the phase will still return exactly, once reacquired and settled. There will however, have been a region of phase error, across which the average frequency will be in error. Both Models 2A-X and 2A-Y take less than one minute for the phase to settle.

Model 2A-Y does alleviate the skywave effects somewhat, due to its lower phase locked loop time constants. Closer to the transmitter, this will not be a problem, either due to the high LUF, at high incident angles, or due to the sheer strength of the groundwave signal. This SC - cut OCXO also confers excellent phase noise above the loop bandwidth.

The new design is so good that one factor limiting its performance was the ferrite rod antenna whose inductance changed with temperature so much that it affected phase stability of the received signal. An entirely new and patent 'H' field small loop antenna with associated amplifier is the solution and whilst slightly less convenient than a Ferrite antenna, has big benefits in supporting the new frequency standards stability.

The loop aerial supplied with all units has been found to be the best type available for this application, achieving excellent temperature performances with no significant phase effects. (In comparison, ferrite rod aerials are very temperature sensitive and will contribute significantly to the phase noise in the system).

The loop aerial and its associated active components are powered with DC via the BNC aerial connector, eliminating the need for a separate power supply. In the event of an accidental short circuit occurring at the BNC socket, protection is afforded by an internal, 20mm fuse, which may readily be replaced.

When setting up the aerial, open the loop out to achieve the maximum area possible (a circle is obviously the optimum but, providing it is reasonably open, the actual shape is not critical). The plane of the loop should be oriented until the transmitter also lies in that plane. Under this condition, the enclosed magnetic field strength of the received signal (and hence the indicated, received signal strength) will be a maximum.

Sensitivity is likewise markedly improved as is immunity to RFI. The result is stability for the 2A-Y (OCXO version) of a few parts in 10^{-11} at ten or a hundred seconds and 10^{-12} per day for 162 kHz (France Inter)

Both low distortion sine wave and square wave outputs are provided at all frequencies 1MHz, 5MHz and 10MHz. One amazing parameter for this frequency standard is the launch price which for the 2A X is expected to be half that of its predecessor. Confidence in performance is quality assured as Quartzlock use their own Passive Hydrogen Maser as an in-house reference which is NPL certified (stability is parts in 10^{-14}) The performance of the new 2A-X and 2A-Y meet tracking receiver stability standards.

The low cost of these frequency standards enables an ensemble of receivers to provide a highly redundant, internationally traceable, reference metrology standard.

Applications involve calibration of frequency meters, counter timers, synthesised signal generators and radio communications test sets for GSM, PMR, PCS and BTS commissioning.

Quartzlock pioneered the use of all Off-Air Standards in the UK as Radio Transmitter base station frequency references - completely eliminating routine calibration and the need for precision offsets in Quasi Synchronous multi Tracking systems for VHF and UHF use.